Hybrid Collaborative Environments for Distributed Decision Making

Collaboration and Knowledge Management Workshop
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Overall Objectives and this year's Objectives

Specific Objectives

Theoretical Objectives

- Deepen theory of Distributed Cognition
- Deepen theory of Coordination
- Lay basis for a theory of Environment design

Specific Objectives: experimental

Experimentally discover factors affecting:

- **3rd man out** – what causes it, how to minimize it
- **Errors** during collaboration – cause, methods of recovery, how to design to reduce their negative effects
- **Interruptions** – when, why, and how to recover
- **Opportunistic discovery** of useful ideas

Specific Objectives: experimental

Experimentally discover factors affecting:

- **Attention Management**
- **Coordination** when designing and then executing a knowledge task
- **Trust** -- increase the level of trust between geographically distant team members
- **Information flow** among individuals of different rank
- **4th Man in:** how to pass the bubble in meetings

Definition of Key Terms
&
Conceptual Models

Key terms

- Distributed cognition
  - the theory that cognition is not uniquely in the head but is distributed over interactions an agent has with resources in his immediate environment, and over interactions with other agents.
  - The theory presupposes that the environment of action is saturated with cultural constraints on conduct, and shared knowledge of how to use tools and other resources. These tools, resources, and other cultural artifacts, such as rules, roles, techniques, simplify performance of tasks because they incorporate adaptations to tasks.

Key Terms

- Opportunistic discovery
  - information that is noticed on another person's screen that seems to be relevant to one's own task.
- Hybrid Environment:
  - An environment that has been enhanced with digital elements such as e-paper, virtual or telepresence, digital projections, shared desktops, shared mice, etc. It may be in a single venue or distributed over several.

Key Terms

- Attention management:
  - one person (or agent) manipulating the environment of another to attract attention to specific elements. Typically this is done by speaking or by pointing. But it can also involve more wholesale manipulation such as
    - controlling projections, jiggling elements, changing a color, causing movement.
    - Implicit or long term attention management is done through setting up or preparing an environment, which can control the steps or timing of steps different team members will take.

Key Terms

- **Coordination theory**:
  - a facet of distributed cognition and also organizational theory which explains how individuals or groups manage the disparate elements of their environments so as to keep on track toward a goal.
  - At a micro level individual people rely on explicit or implicit representations of all kinds to manage themselves & stay on task:
    - Explicit: to do lists, forms, guidelines, annotations, talking out loud to themselves or others
    - Implicit: internalized rules, roles, spatial arrangements of resources, production lines.
  - At a social level, groups stay on task by relying on
    - roles, leaders or managers, monitors and critics, attention management techniques, shared representations, forms, production lines, conductors, rules regulations, shared cultural understanding etc.

Key Terms

Deep structure of environments

- Layout and nature of info entry points. An entry point is an information or task attractor in an environment.
  - A pile of files on a desk
  - Open email window
  - Telephone
  - Open to do list
- Organizational principles governing containers
  - 'Paper clipped' papers
  - Filing cabinets
  - Arrangement of books or papers on shelves
  - Tacit organization of piles
- Background factors that set the stage and constrain activity
  - power relations,
  - trust, cultural expectations and individual differences in understanding, experience and interpreting (projecting structure)

Key Terms

- Surface Structure of an Environment
  - Surface attributes of environment
    - Color coded files vs. explicitly labeled files
    - Clipped papers vs. stapled papers
    - Height, width, length of desk
    - Number of shelves
    - Design of filing cabinets

Expected Final Products

Final Products

1. Theoretical products:,
   - Metrics: visualizing level of coordination, errors, interruptions, trust, opportunistic activity
   - Articles & Theoretical models
     - Extend theory of distributed cognition
     - Coordination Theory
     - Principles for understanding and designing Environments

Final Products

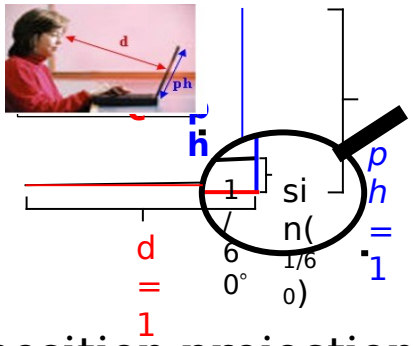
- Practical Objectives:
  - Guidelines for creating more effective distributed environments in which:
    - Fewer 3rd man out issues
    - Better error recovery
    - Better interruption recovery
    - Better coordination
    - How to facilitate opportunism
    - Tools for attention management
    - Tools for meeting capture and passing the bubble

Final Products

Practical Objectives

Develop **guidelines**

- How to design cognitively friendly environments for geographically distributed collaboration.
- Principles for constraining design space. Relative layout.



- How to position projections relative to work surfaces

Software Products

1. Software products:
   - Capture tools for reviewing, improving decision making
   - Experimental tools for analyzing activity and applying metrics
   - User tools for reviewing past meetings faster and more effectively than through minutes
   - Improvements to access grid

Experiments

Experimental Plan

- Construct technologically sophisticated collaborative environments, including new software tools (Our testbed)

Construct Sophisticated Collaborative Environments

- Single and multiple venue applications of the Access Grid enhanced with
  - Special capture tools
  - Special collaborative software tools

VisLab

Conference Room (SDSC)

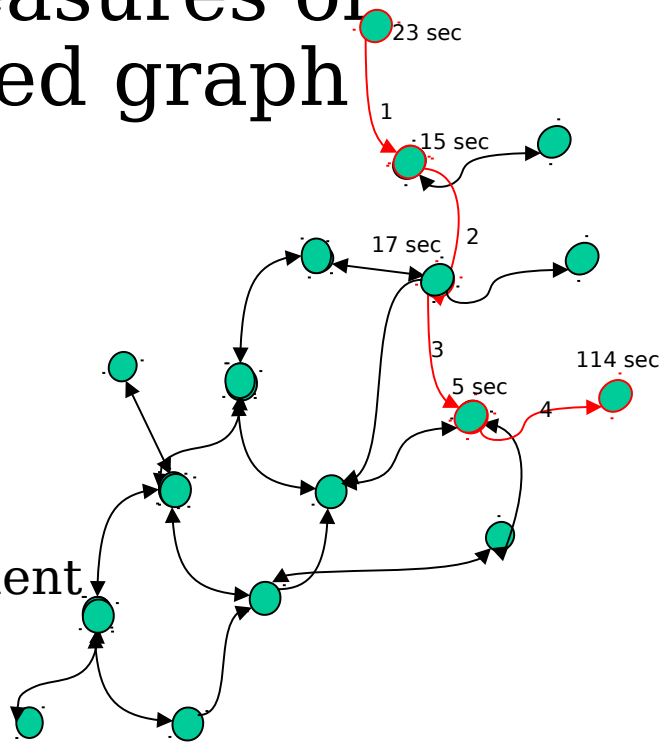
Observe and Measure

- Observe subjects using new techniques of digital ethnography
  - Digitally capture all activity
    - Video of subjects
    - Video of desktops
  - Develop new methods for reviewing this huge amount of data (120 hrs of video)

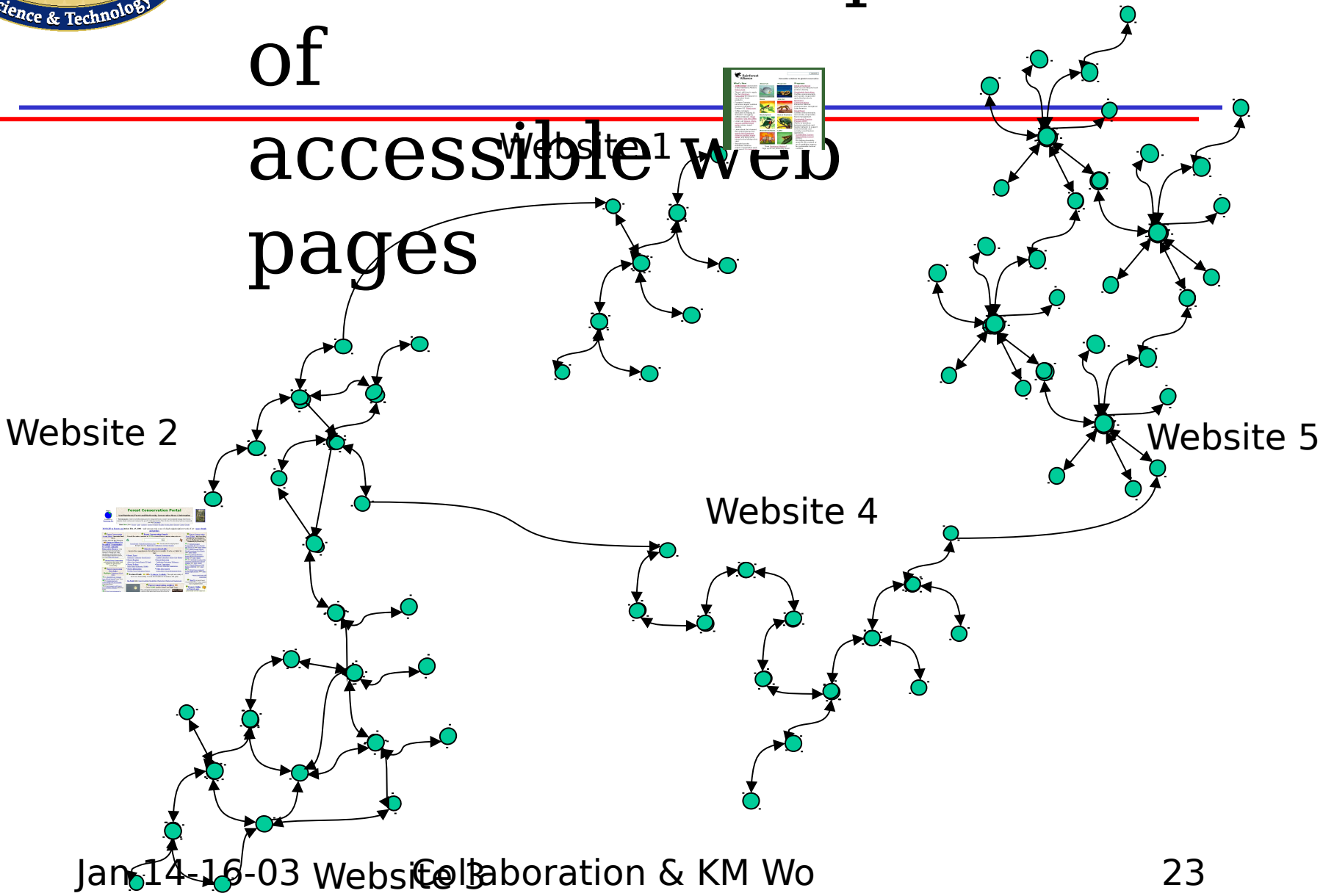
    media review tool (alt enter)

New Methodology

- Compare ethnographic observations with quantitative measures of behavior on connected graph
  - We record
    - Time at node
    - Sequence of nodes
    - Mouse timings
      - Mouse over links
      - Onset of mouse movement
    - Keystroke timings



Connected Graph of accessible web pages

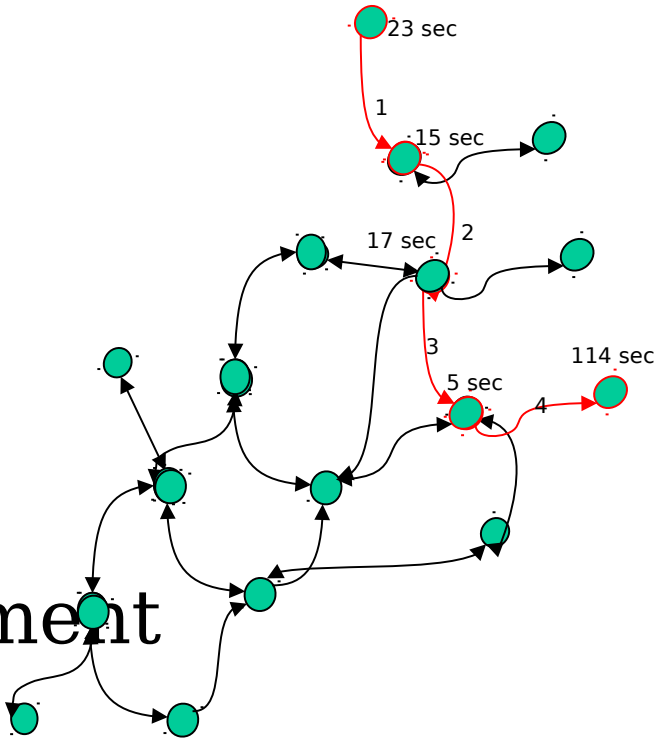


New Methodology ..cont

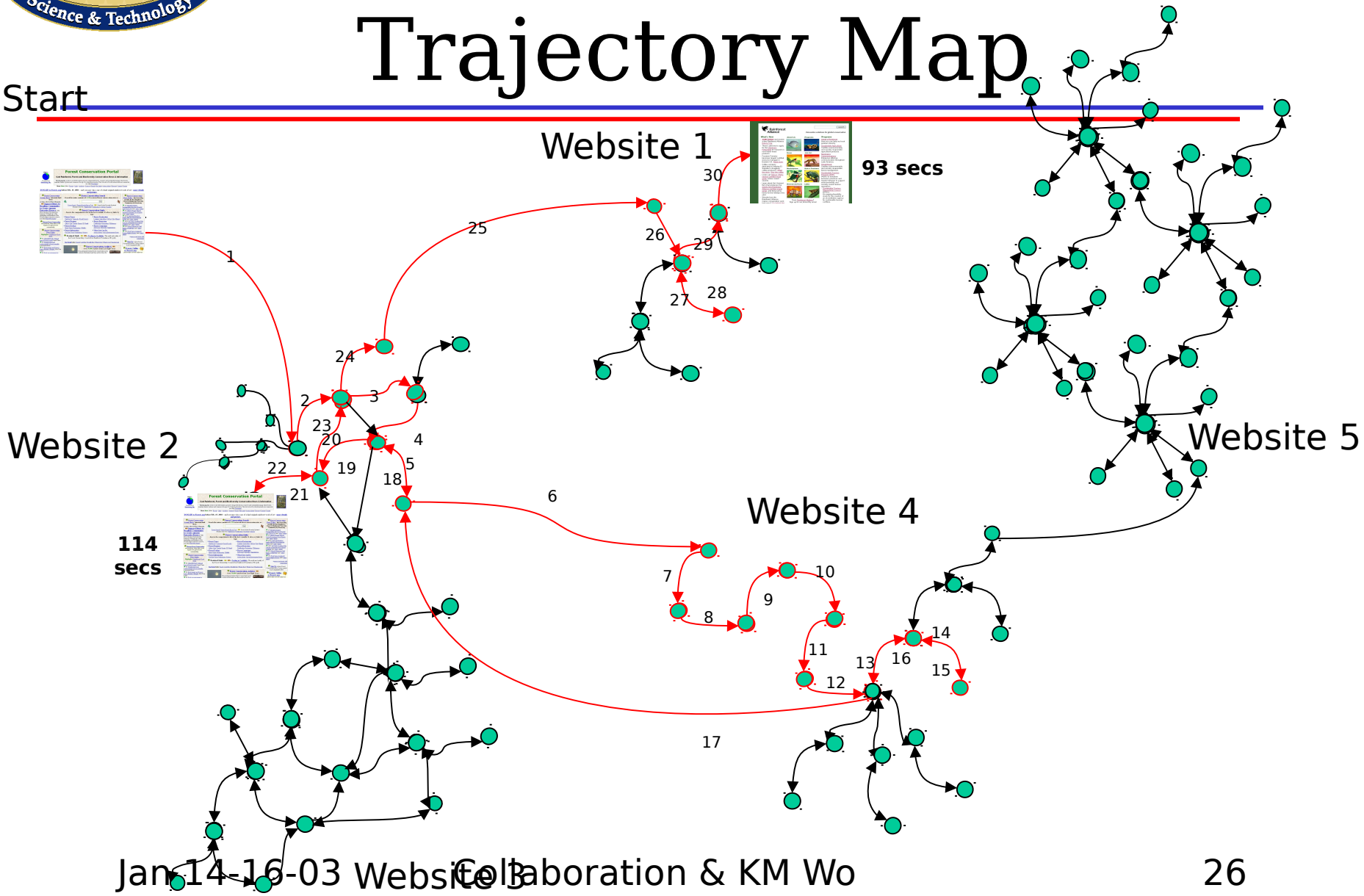
1. Give subjects a starting portal
2. Serve pages using a proxy server which
   a. Restricts linking to circumscribed set of pages
   b. Times when pages are requested
3. Time keystrokes, mouse activity
4. Define new predicates over behavior (e.g. av time per page)
5. Operationalize key collaborative phenomena in terms of new predicates
6. Go back and forth between ethnographic and quantitative observations

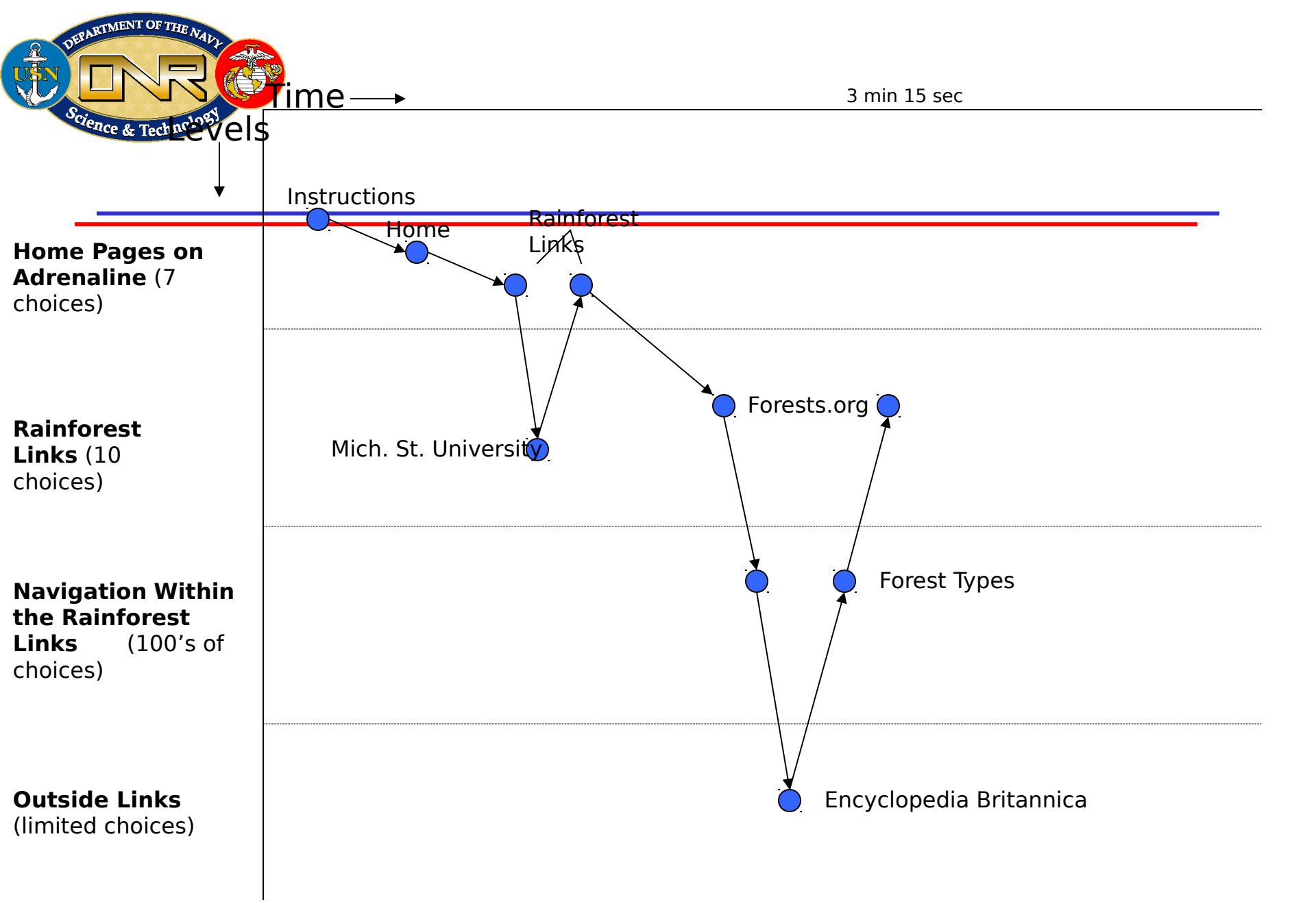
We Record

- Time at node
- Sequence of nodes
- Mouse timings
  - Mouse over links
  - Onset of mouse movement



Trajectory Map




Time
3 min 15 sec
Levels
Instructions
Home
Rainforest Links
Home Pages on Adrenaline (7 choices)
Forests.org
Mich. St. University
Rainforest Links (10 choices)
Forest Types
Navigation Within the Rainforest Links (100's of choices)
Encyclopedia Britannica
Outside Links (limited choices)

Advantages of using a connected graph model

- Data mine and compare paths through graph
- We can define arbitrary predicates:
  - Av Time per page,
  - time per page as function of textual weight
  - Time per page as function of graphical weight
  - Relative or average time per website
- We can operationalize variables wrt predicates

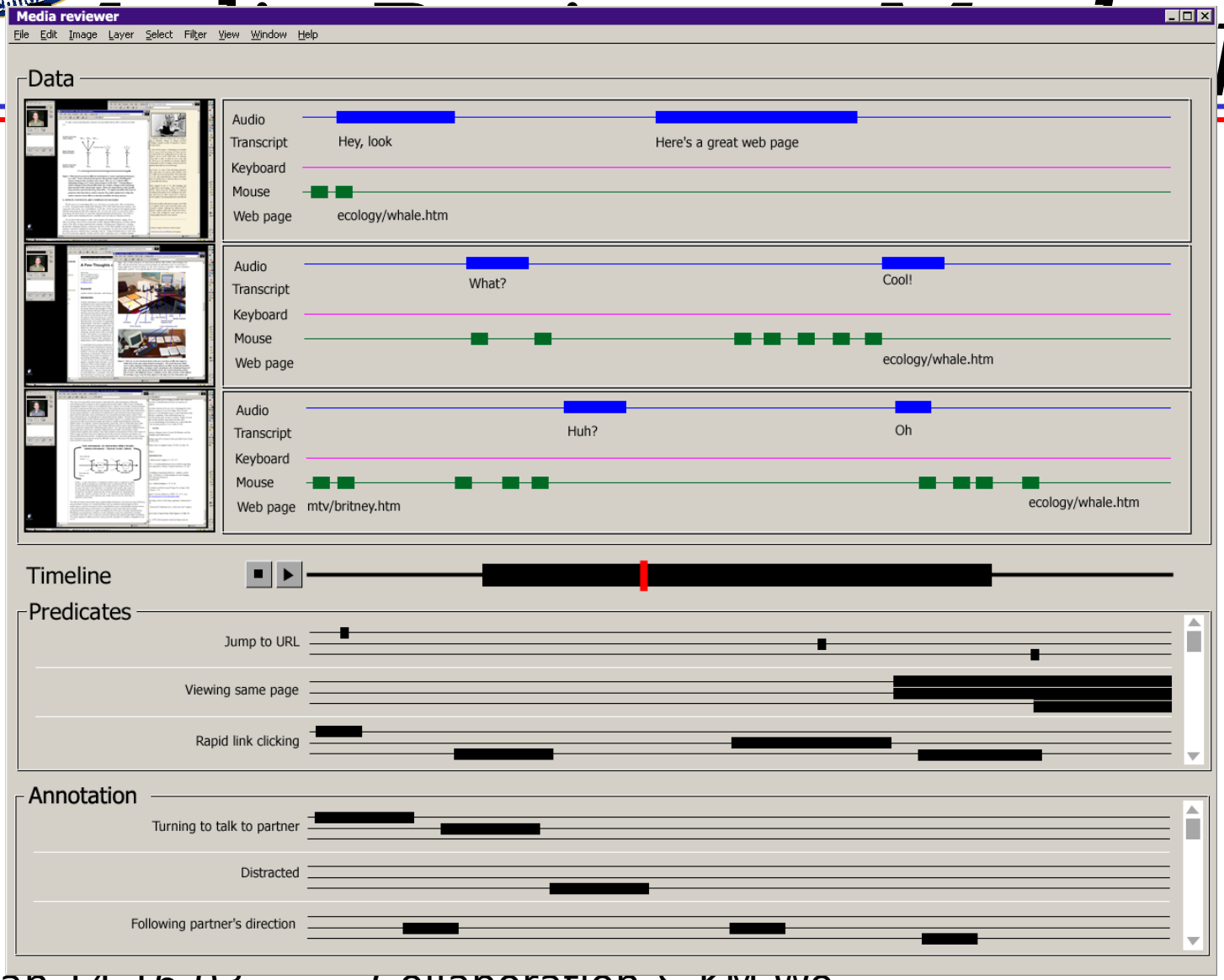
Operationalizing Key Variables

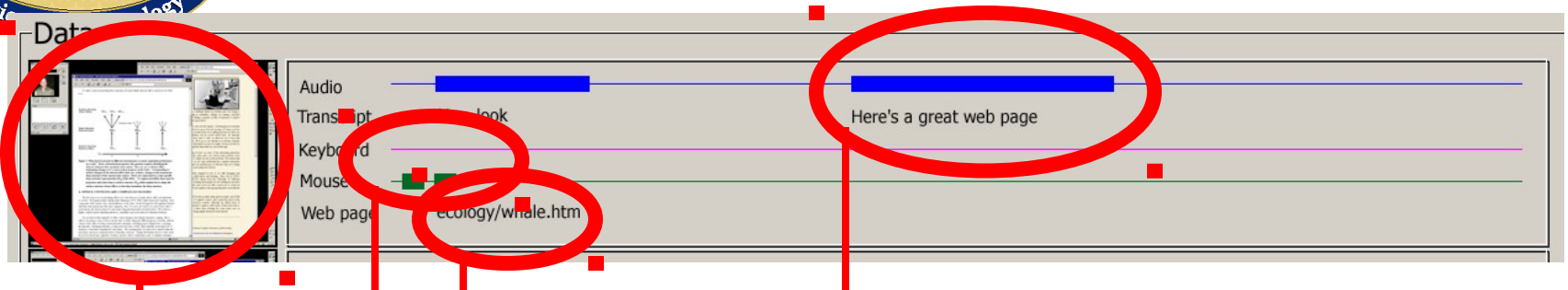
- Opportunistic use of another's work
  - Idea: I see something useful on his display
  - Behavior:
    - I visit the same node myself (measure lag between your time at that node and mine)
    - I ask a question about that info/subject
    - I request the link, or request that he copy it to the shared directory
    - I enter his window (with mouse anywhere) and
      - attention manage while I speak
      - I copy the link, some text, an image for my own use

Interruption and Interruption Recovery

- Interruption – define ethnographically
  - Conversational
  - Task shift
  - Attention request
  - …
- Interruption recovery
  - Return to mouse in same node

Software and other supporting tools developed


Media reviewer
File Edit Image Layer Select Filter View Window Help
Data
Audio
Transcript
Hey, look
Here's a great web page
Keyboard
Mouse
Web page
ecology/whale.htm
Audio
Transcript
What?
Cool!
Keyboard
Mouse
Web page
ecology/whale.htm
Audio
Transcript
Huh?
Oh
Keyboard
Mouse
Web page
mtv/britney.htm
ecology/whale.htm
Timeline
Predicates
Jump to URL
Viewing same page
Rapid link clicking
Annotation
Turning to talk to partner
Distracted
Following partner's direction



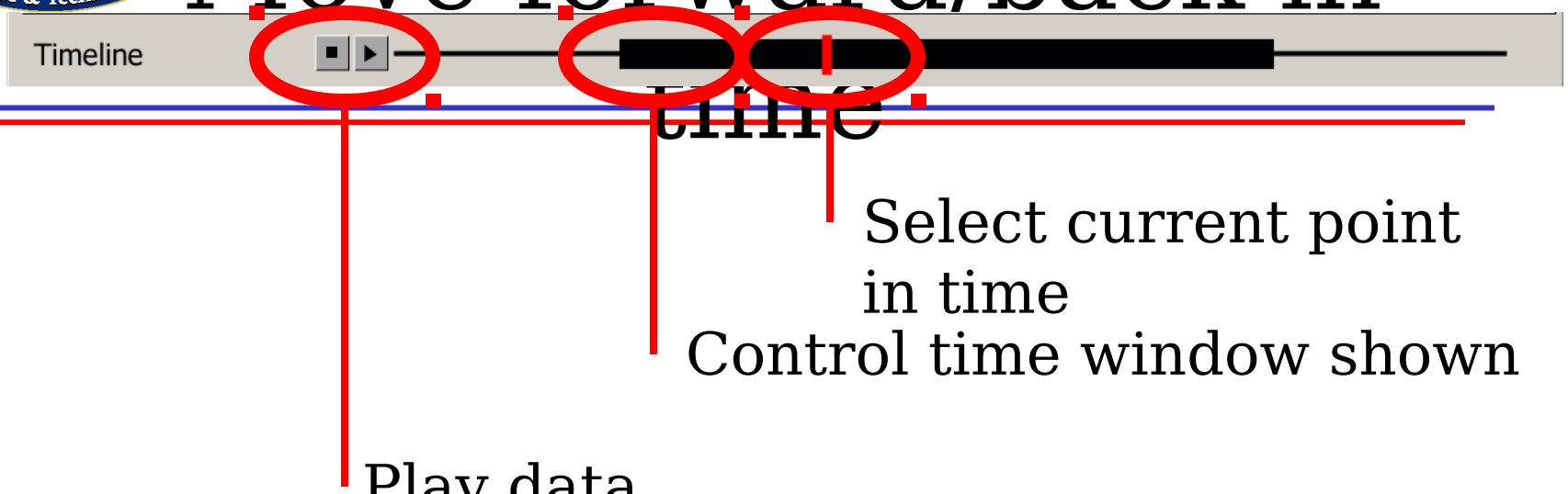
Review audio and transcript

Monitor task state

Watch keystrokes and mouse events

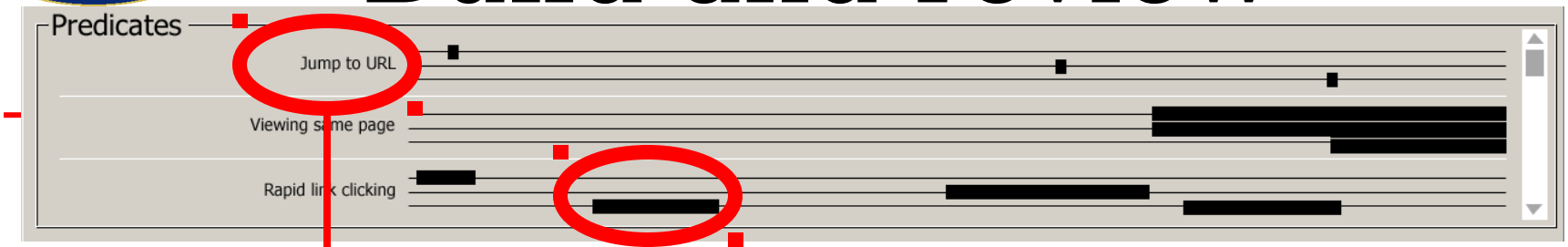
Play digital video of user's screen

Move forward/back in time



- Scan forward and back in time
- Play in real time
- Jump
- Zoom in/out on even stream

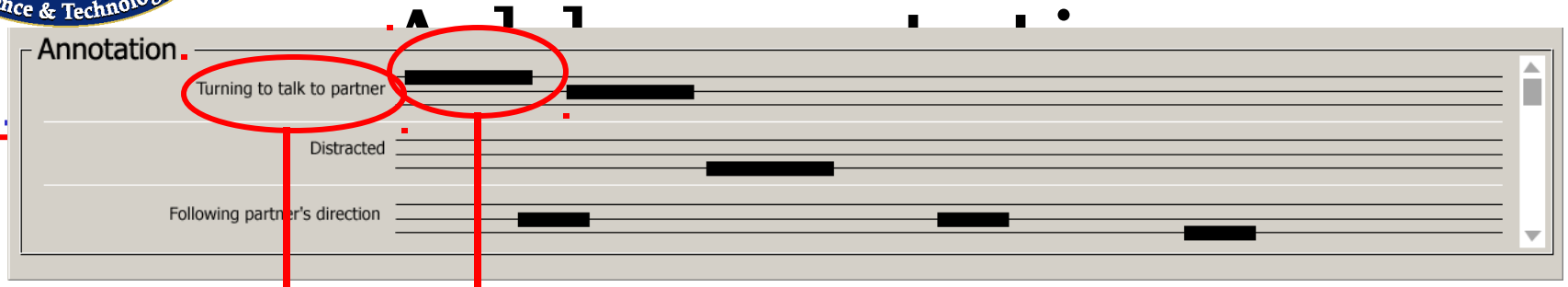
Build and review



Show times when predicate is true

Show a predicate name

- Predicates are queries that return true/false on data conditions
  - "Jump to URL" is true on each Web page transition
  - "Viewing same page" is true when ≥2 people view same Web page
  - "Rapid link clicking" is true during fast page

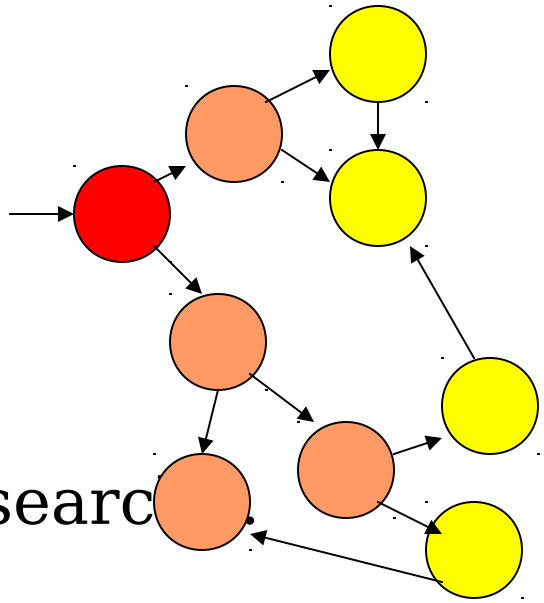


Mark or name regions of interest

Show an annotation channel name

- Annotations mark events, interesting areas, etc.
  - Added by a reviewer, not an algorithm
  - Note types of interaction, who is talking to whom, etc.

Visualize Task Progress



- For tasks that involve Web site searc
  - Monitor pages viewed by a proxy server
  - Plot site and color by # of visits, time spent, # of users visiting…

Progress: Experimental

Experiment	Number Completed	Number Predicted
1 - One Venue - No Projection - Itinerary	**5**	**5**
2 - One Venue - No Projection - PowerPoint	**7**	**5**
3 - One Venue - PowerPoint	**6**	**5**
4 - One Venue - Itinerary	**29**	**5**
5 - Multi Venue - Itinerary	**9**	**5**
6 - Multi Venue - PowerPoint	**3**	**5**
7 - Mouse Anywhere - One Venue - Itinerary	**pilot**	**5**
8 - Mouse Anywhere - One Venue - PowerPoint	**pilot**	**5**
9 - Mouse Anywhere - Multi Venue - Itinerary	**pilot**	**5**
10 - Mouse Anywhere - Multi Venue - PowerPoint	**pilot**	**5**
	59	**50**

Progress: Technical

Products: New Software Developed

1. Conversion tool for generating QT files from VNC input
2. Conversion tool for generating QT files from AG input
3. Media review tool
    1. Synchronize 6 video streams
    2. Synchronize multiple audio and video streams
    3. Display audiograph
    4. Create event streams, with bookmarks and annotations (in progress)
4. Mouse anywhere
    1. 1 venue
    2. 2 venues (flakey)

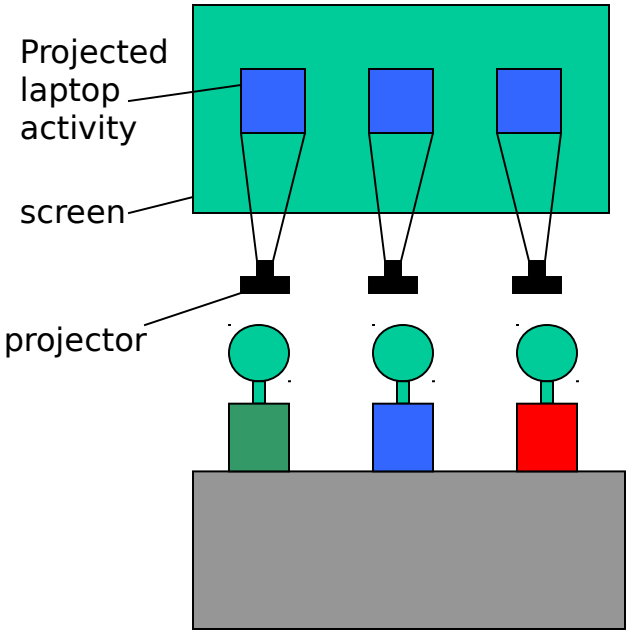
Some Findings and Predictions

Predictions

- Opportunism and sharing will increase with larger more immersive projection screens
  - Subjects will no longer prefer their laptops screens (assuming angles of viewing are appropriate)

Observation

Participants do not look at the shared projection scre



Three Phases of Activity

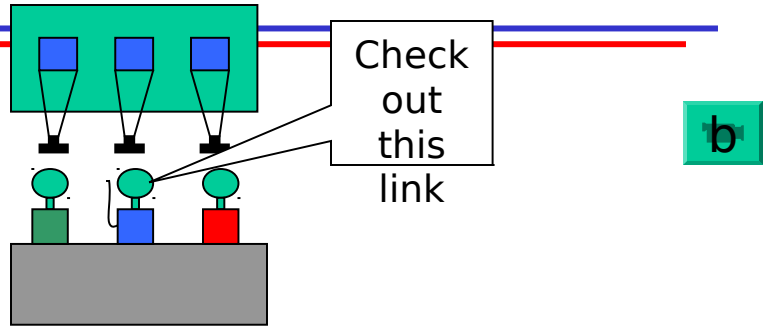
Frequency of looking at the shared projection screen is different.

1. **Beginning**: Participants strategize how they are going to divide up the tasks and responsibilities.
2. **Middle**: Subjects gather information and conduct Individual research.
3. **End**: Subjects collaborate their individual work and create a single, final product.

Observed:

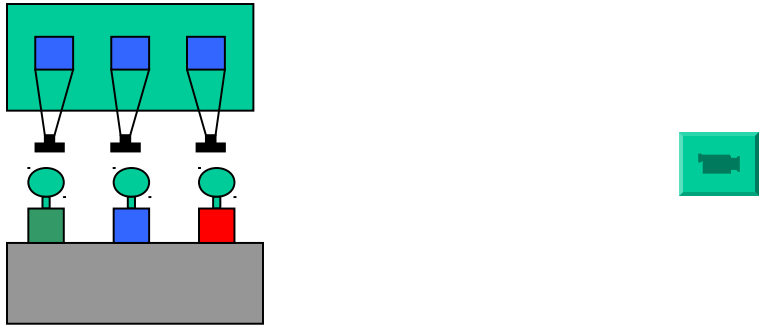
Beginning

Occasional use for reference.



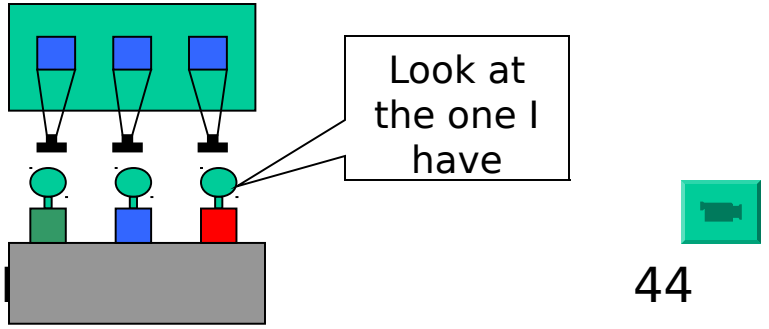
Middle

Very sparse use of the screen. Subjects intently use their own laptops or glance at another subject's laptop if they require information.



End

Occasional use for reference.

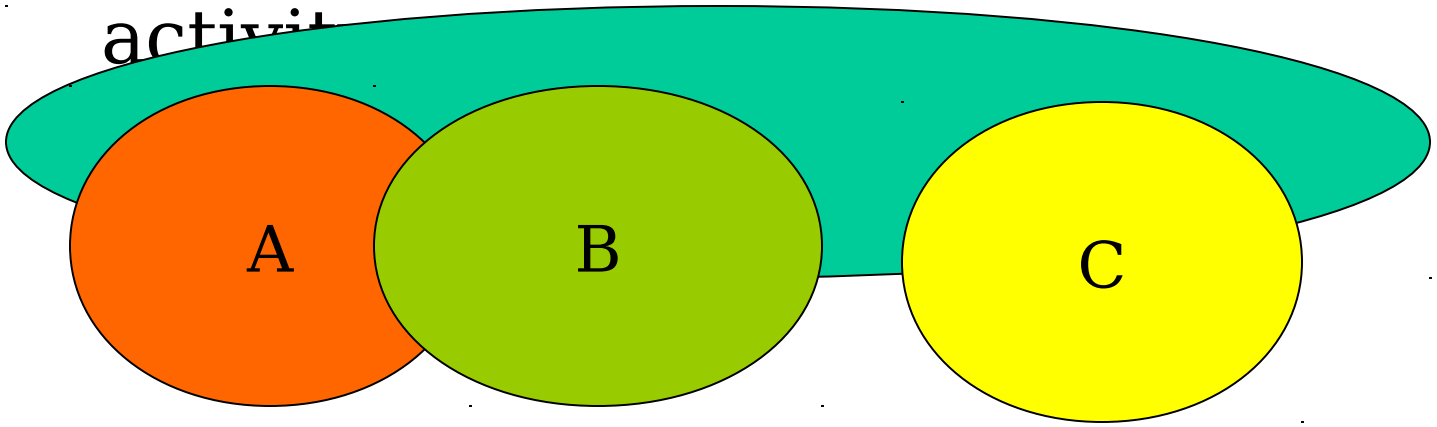


Conjecture

- The screen is too hard to see.
  - If resolution and brightness of projection is *matched* with the laptop specifications, the experiment participants will look at the shared projection screen more during all phases of the experiment.
  - If the projection resolution was *better* than the resolution on the laptops, an even larger increase in participant screen use would be observed.

Prediction

- Coordination may be increased in distributed environments
  - Fewer assumptions of shared knowledge of group context of activit

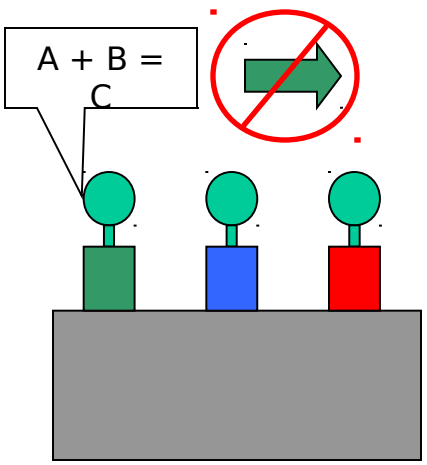


3 Types of Errors

Three types of information sending/receiving err

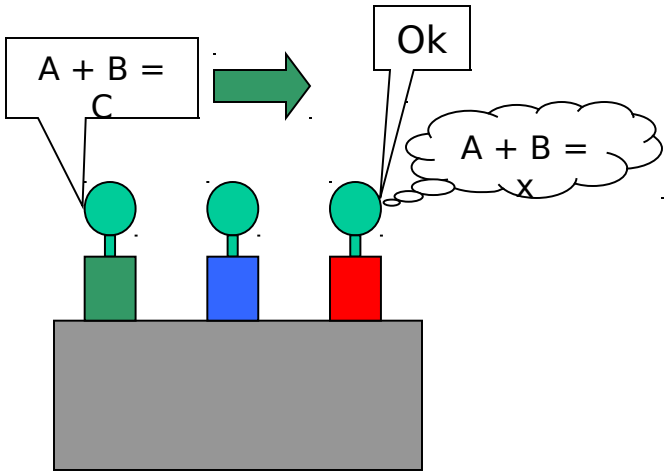
Type 1

Signal not across - - no confirmation



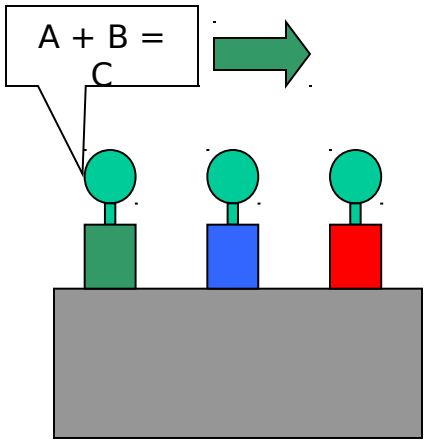
Type 2

Signal across - - confirmed - - but misinterpreted



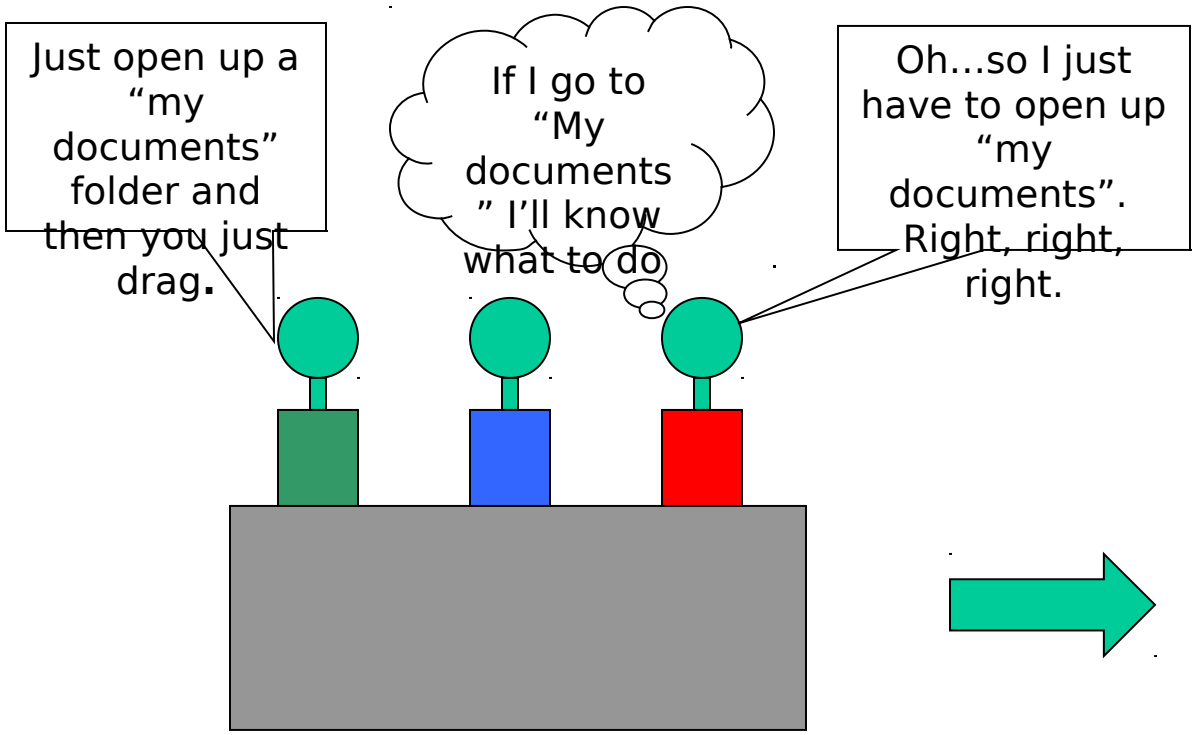
Type 3

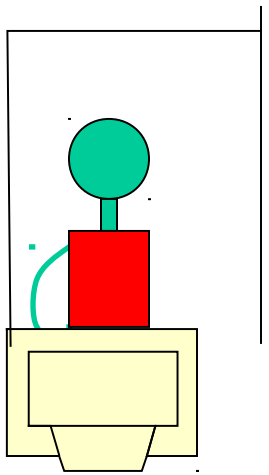
Signal across - - no confirmation



Example of Type 2 Error

Signal Sent → **Signal Received But Misinterpreted** → **Errant Action**


Just open up a "my documents" folder and then you just drag.
If I go to "My documents " I'll know what to do
Oh…so I just have to open up "my documents". Right, right, right.



Doesn't drag file from "my documents" to shared the folder, "subject files"

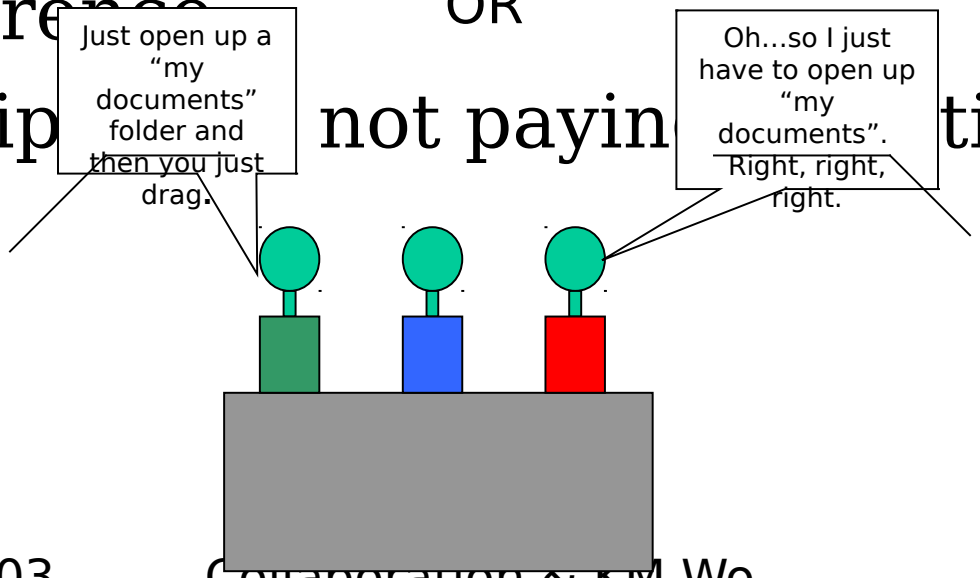
Click for Video

Click for Video

Reasons for Type 2 Error

- Two possible explanations for type 2 error
  - One person assumes a shared reference
  - Recipient not paying attention

OR

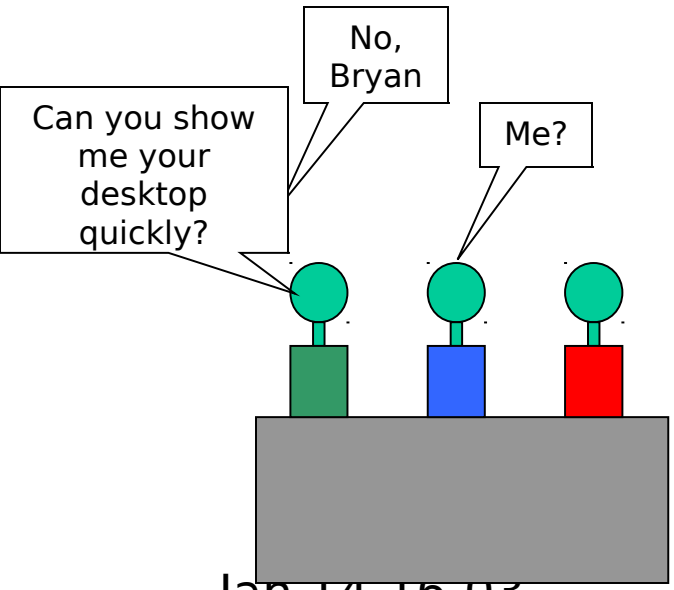


He assumes they are sharing the same knowledge and reference to file sharing procedures and thus "you just drag" would be enough to articulate the instruction

Cuts him off with a strong confirmation "right, right, right." Doesn't hear "you just drag"

- **Conjecture:** Type 2 error is reduced in the distributed environment because the constraints force more explicit communication and resolve deictic reference and inattention.

Evidence:



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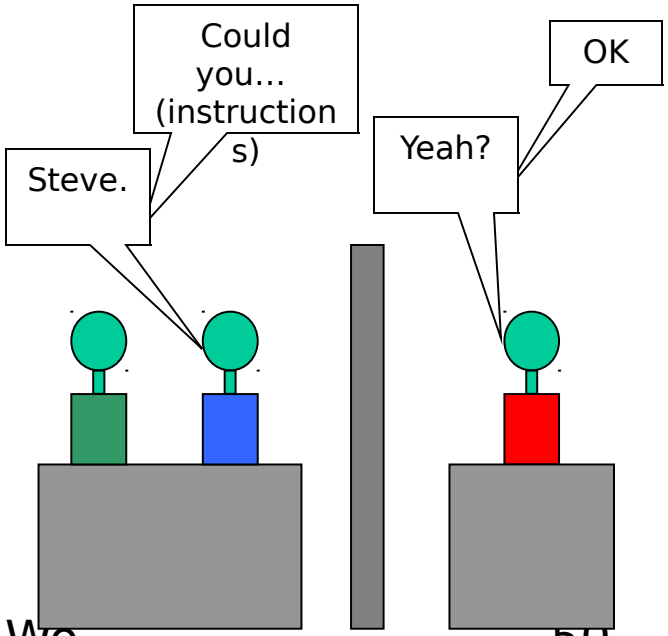
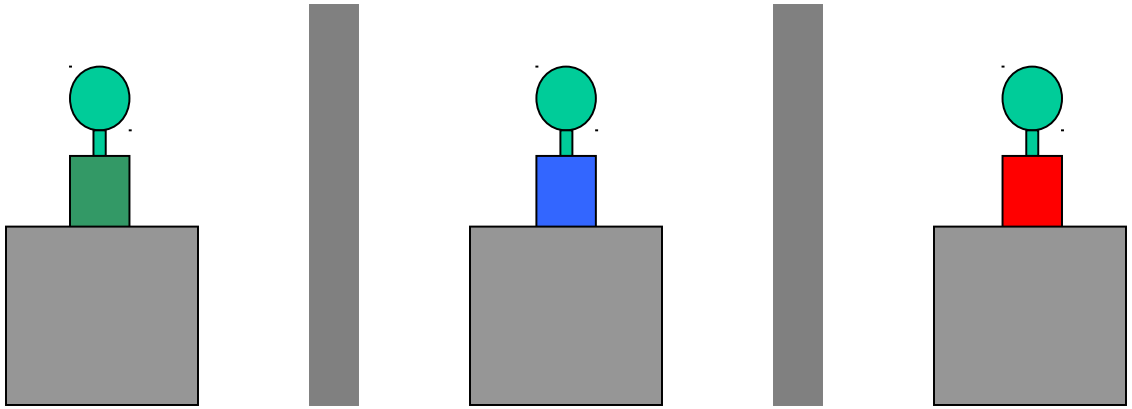


Click for Video

- **Conjecture**: A more distributed setting will reduce type 1,2,and 3 errors.



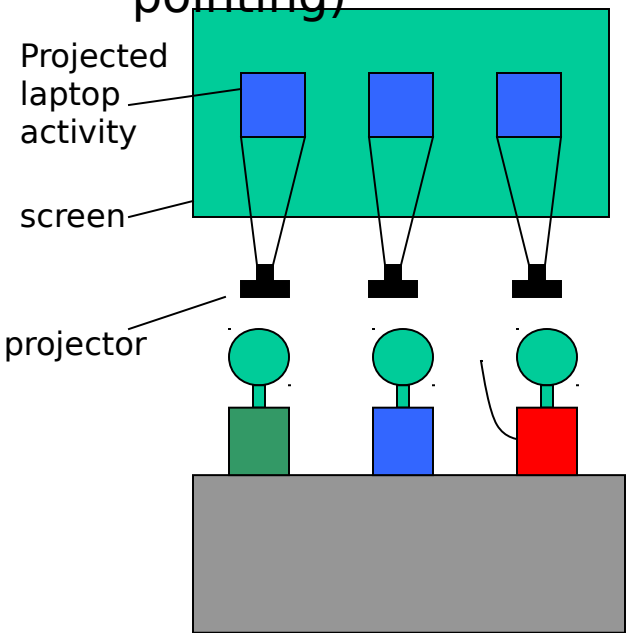
Prediction

- Mouse anywhere will increase the amount of attention to the projected screen

Observation

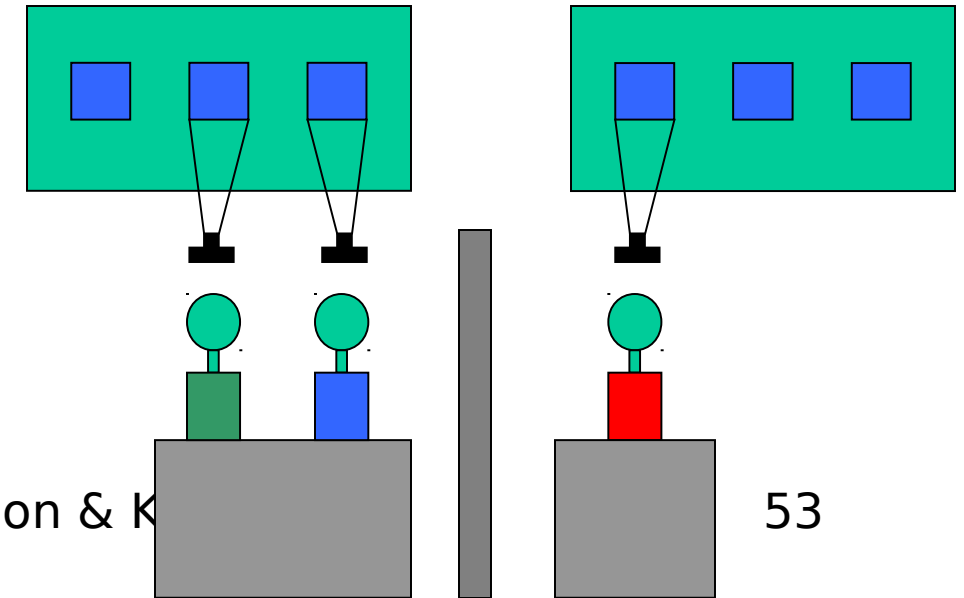
Collaborative

(More viewing and pointing)



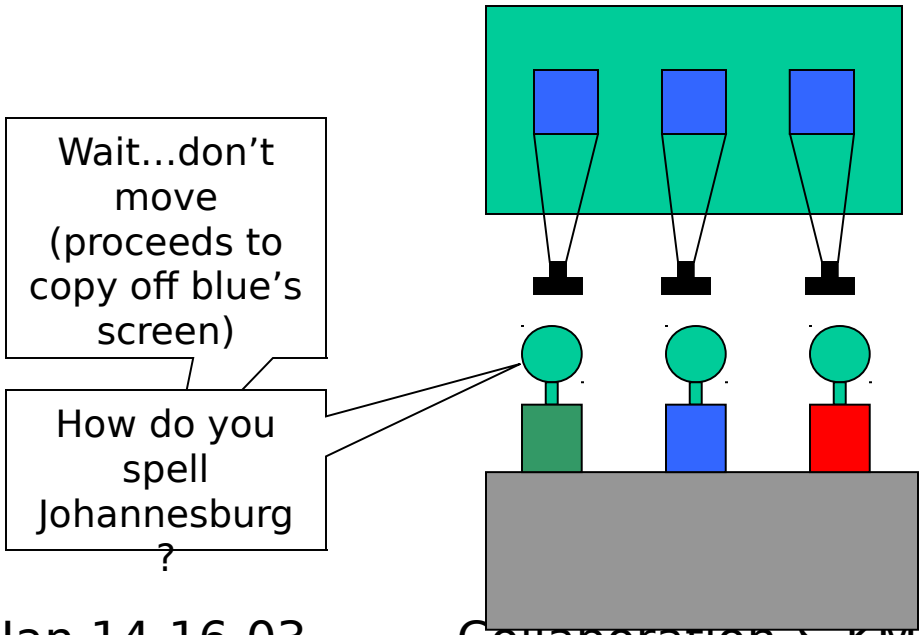
Distributed

(Less viewing and pointing)



One Venue

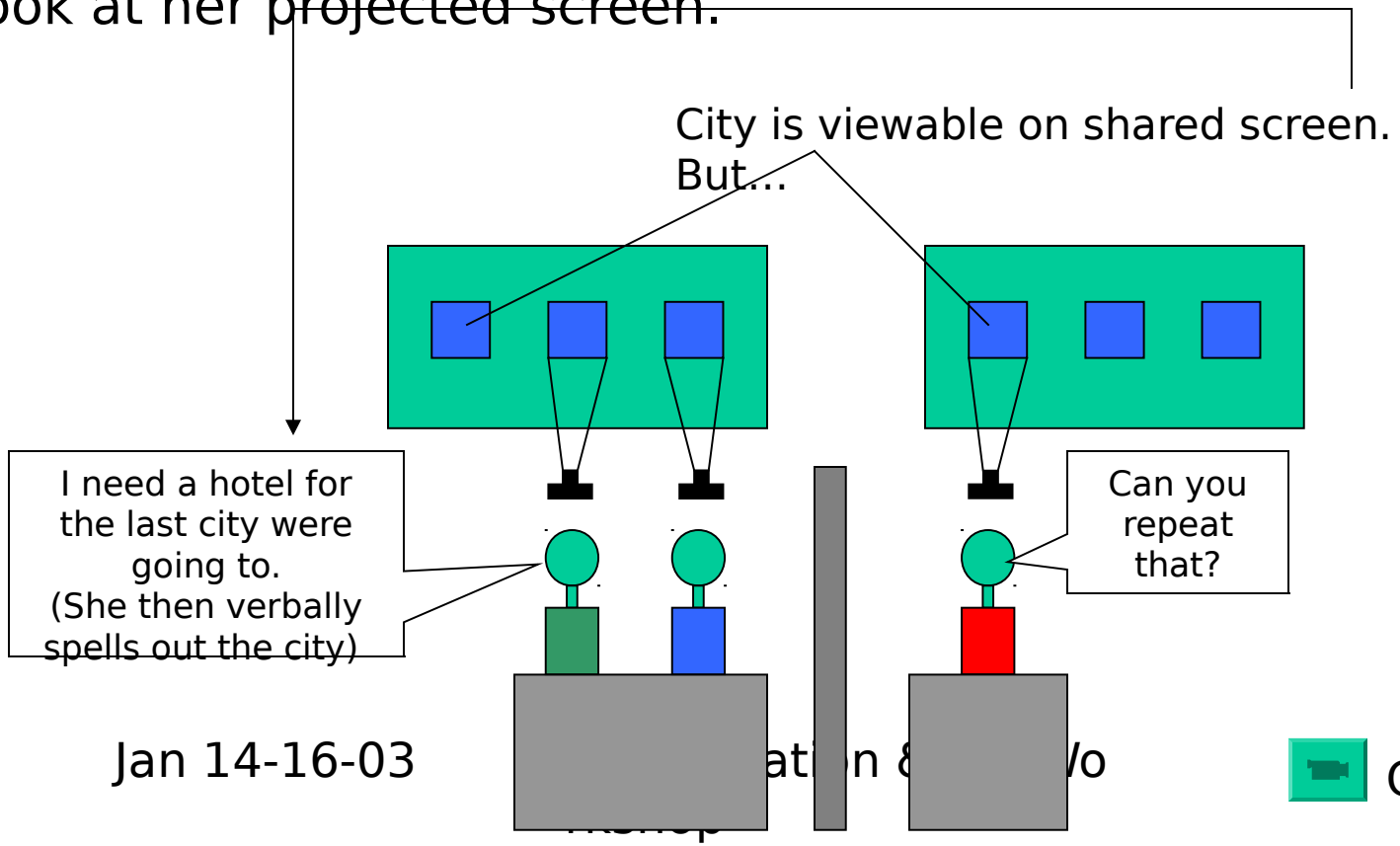
Green needs to figure out how to spell Johannesburg.
He sees Johannesburg on blue's screen.
He asks blue not to go anywhere as he views her screen and writes down the correct spelling.



Click for Video

Two Venue

Green needs the red subject to find a hotel in the last city they will be visiting.
Green then spells out the name of the city instead of telling red to look at her projected screen.


City is viewable on shared screen.
But...
I need a hotel for the last city were going to.
(She then verbally spells out the city)
Can you repeat that?

- Conjecture: “mouse anywhere” experiments in distributed environments should show increased interaction with projection screen.

Project Status

Progress: Experimental

Experiment	Number Completed	Number Predicted
1 - One Venue - No Projection - Itinerary	**5**	**5**
2 - One Venue - No Projection - PowerPoint	**7**	**5**
3 - One Venue - PowerPoint	**6**	**5**
4 - One Venue - Itinerary	**29**	**5**
5 - Multi Venue - Itinerary	**9**	**5**
6 - Multi Venue - PowerPoint	**3**	**5**
7 - Mouse Anywhere - One Venue - Itinerary	**pilot**	**5**
8 - Mouse Anywhere - One Venue - PowerPoint	**pilot**	**5**
9 - Mouse Anywhere - Multi Venue - Itinerary	**pilot**	**5**
10 - Mouse Anywhere - Multi Venue - PowerPoint	**pilot**	**5**
	59	**50**

Progress: Technical

Products: New Software Developed

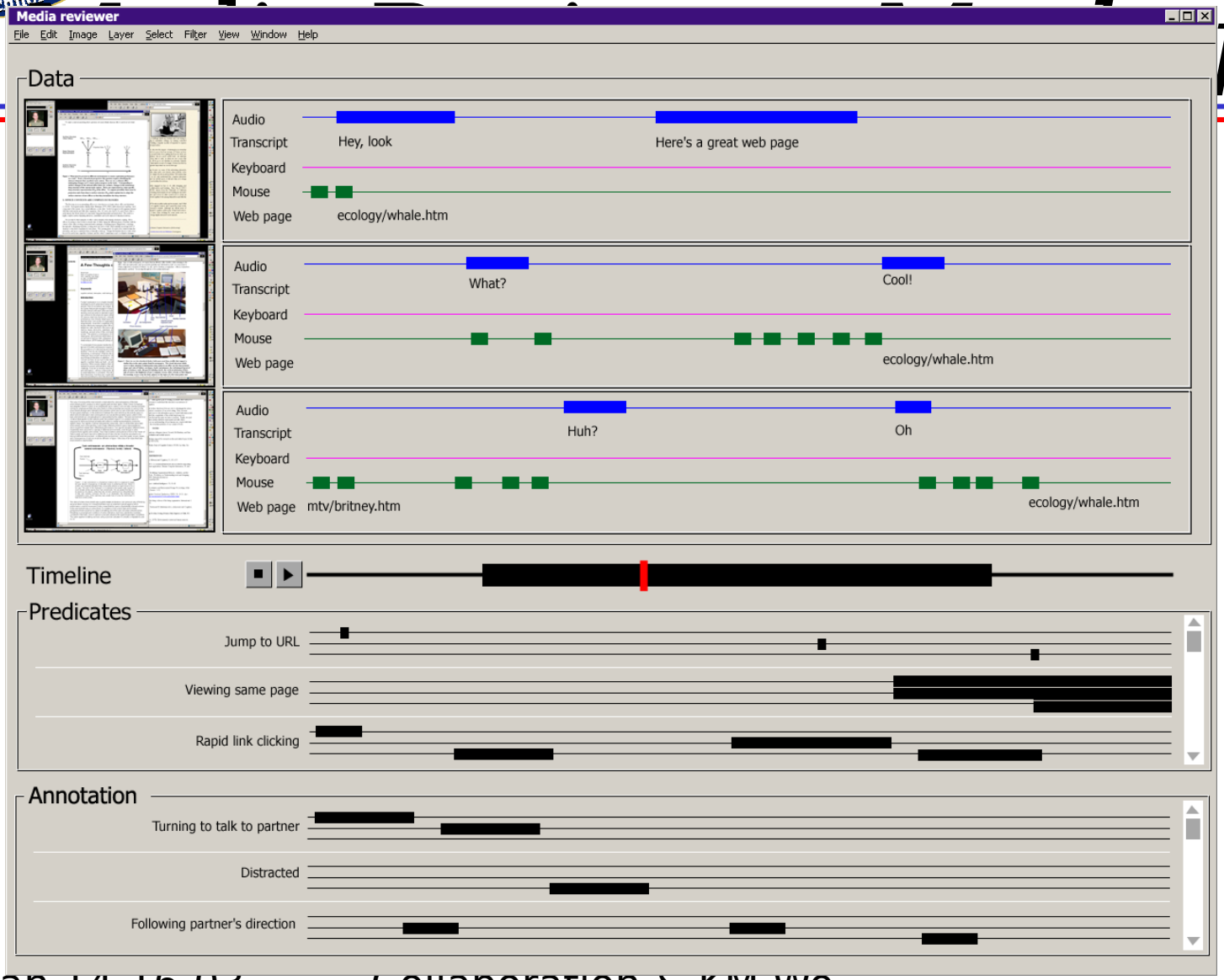
1. Conversion tool for generating QT files from VNC input
2. Conversion tool for generating QT files from AG input
3. Media review tool
    1. Synchronize 6 video streams
    2. Synchronize multiple audio and video streams
    3. Display audiograph
    4. Create event streams, with bookmarks and annotations (in progress)
4. Mouse anywhere
    1. 1 venue
    2. 2 venues (flakey)

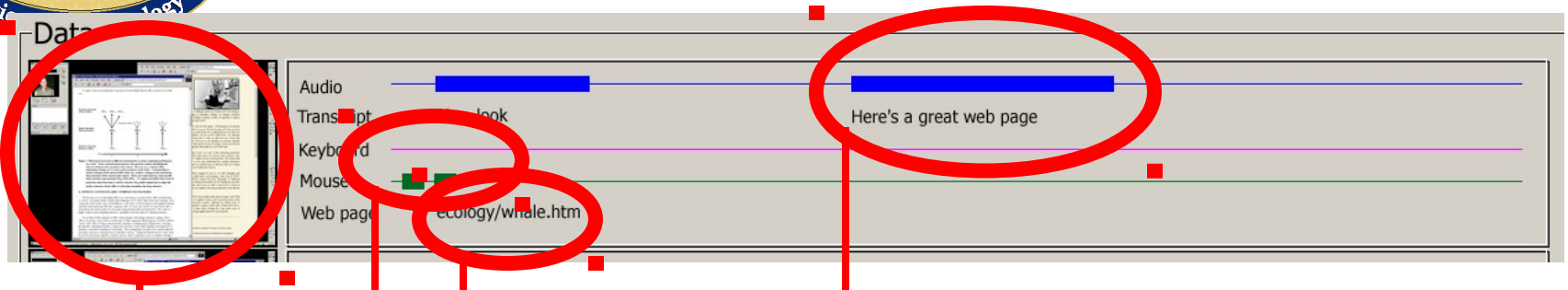
Accomplishments

- Major Accomplishments to date:
  - Working two venue environments with capture
  - 4 software products nearing completion
  - Development of methodology for digital ethnography
- Completed publications and technical reports
  - Kirsh, D., 'The Context of Work', *Human Computer Interaction*, 2001 (Jan 2002)
  - Kirsh, D. Changing the Rules: Architecture in the new Millennium, *Convergence*. 2001

The End

Software and other supporting tools developed


Media reviewer
File Edit Image Layer Select Filter View Window Help
Data
Audio
Transcript
Hey, look
Here's a great web page
Keyboard
Mouse
Web page
ecology/whale.htm
Audio
Transcript
What?
Cool!
Keyboard
Mouse
Web page
ecology/whale.htm
Audio
Transcript
Huh?
Oh
Keyboard
Mouse
Web page
mtv/britney.htm
ecology/whale.htm
Timeline
Predicates
Jump to URL
Viewing same page
Rapid link clicking
Annotation
Turning to talk to partner
Distracted
Following partner's direction



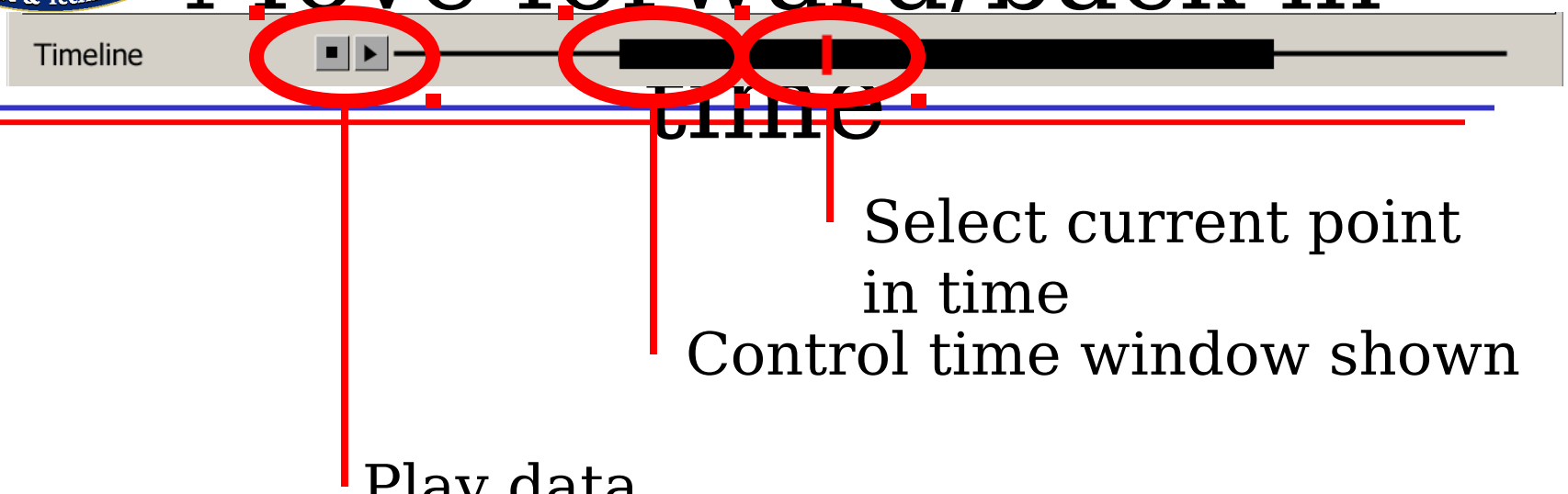
Review audio and transcript

Monitor task state

Watch keystrokes and mouse events

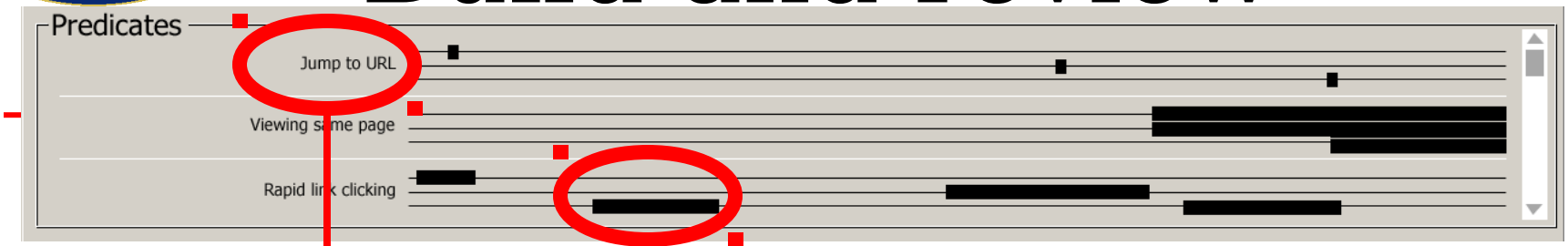
Play digital video of user's screen

Move forward/back in time



- Scan forward and back in time
- Play in real time
- Jump
- Zoom in/out on even stream

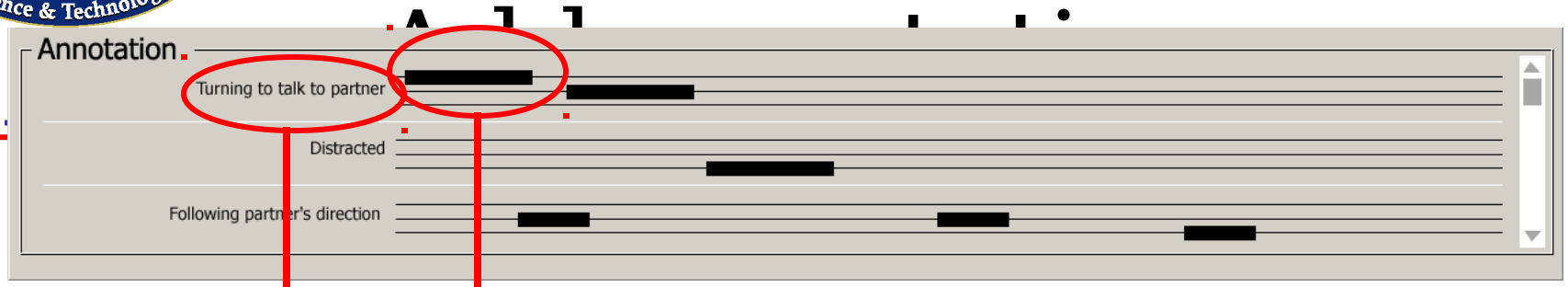
Build and review



Show times when predicate is true

Show a predicate name

- Predicates are queries that return true/false on data conditions
  - "Jump to URL" is true on each Web page transition
  - "Viewing same page" is true when ≥2 people view same Web page
  - "Rapid link clicking" is true during fast page

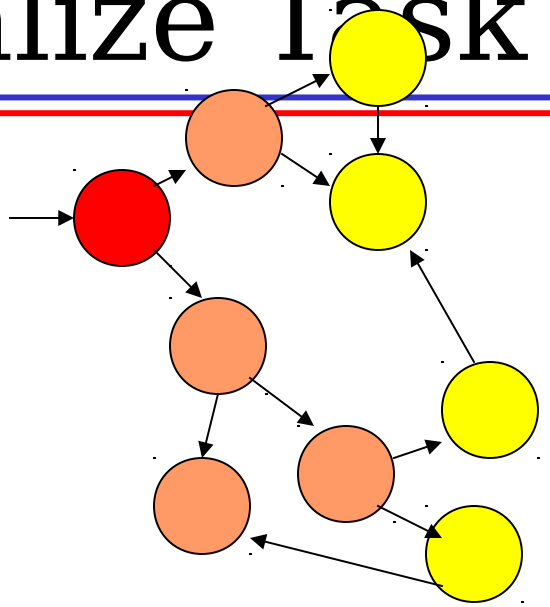


Mark or name regions of interest

Show an annotation channel name

- Annotations mark events, interesting areas, etc.
  - Added by a reviewer, not an algorithm
  - Note types of interaction, who is talking to whom, etc.

Visualize Task Progress



- For tasks that involve Web site search…
  - Monitor pages viewed by a proxy server
  - Plot site and color by # of visits, time spent, # of users visiting…

Future Directions/Payoffs

- FY 2003 Plans
  - Develop new collaboration visualization tools
    - Extend media review tool to include new tracks (audio localization), add bookmarking, annotation of event types (error, interruption, dispute …)
  - Redesign Access Grid venues to benefit from results on projection size
  - Design new set of experiments leveraging Connected Graph

Future Directions/Payoffs

- Deepen work on Attention management using mouse anywhere
  - Build mouse in commons
- Explore effect of practice, team familiarity, and expertise on coordination
- Deepen work on interruption and errors

Participants and Staffing

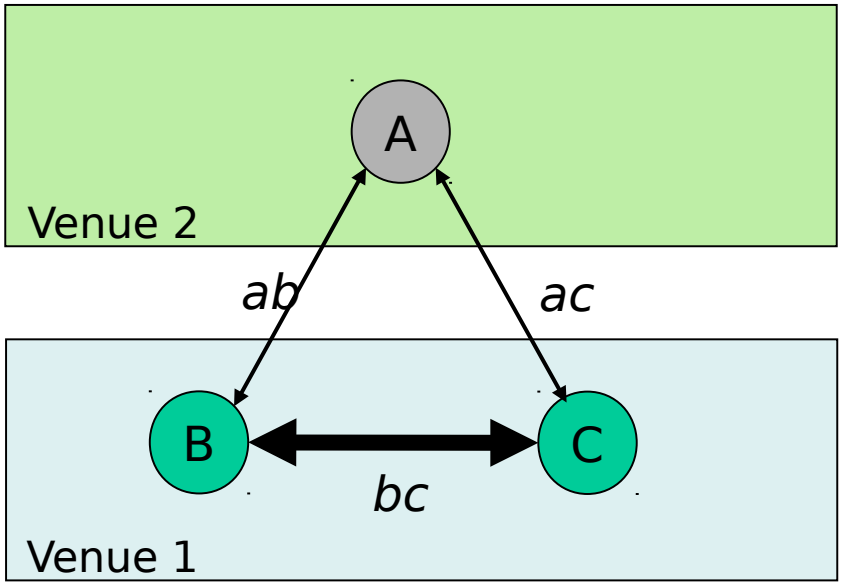
- Participants:
  - UCSD, Dept of Cognitive Science
  - San Diego Supercomputer Center
  - California Institute for Telecommunications and Information Technology
  - Future years: NCSA, Argonne Labs, UC Irvine
- Staffing:
  - Prof David Kirsh UCSD
  - Prof Aaron Cicourel UCSD
  - Dr. Steve Cutchin SDSC
  - Dr. Thomas Rebotier
  - Undergrad tba

Sharpen Focus of Inquiry

- 3rd man out
- 4th man in

3rd Man Out

- Definition:
  - In 2-1 distributed environments the solitary subject interacts less, attends less, is valued less, feels less part of the team, contributes less.
- Methodology
  1. Prove the phenomena
  2. Identify causes
  3. Propose and test repairs



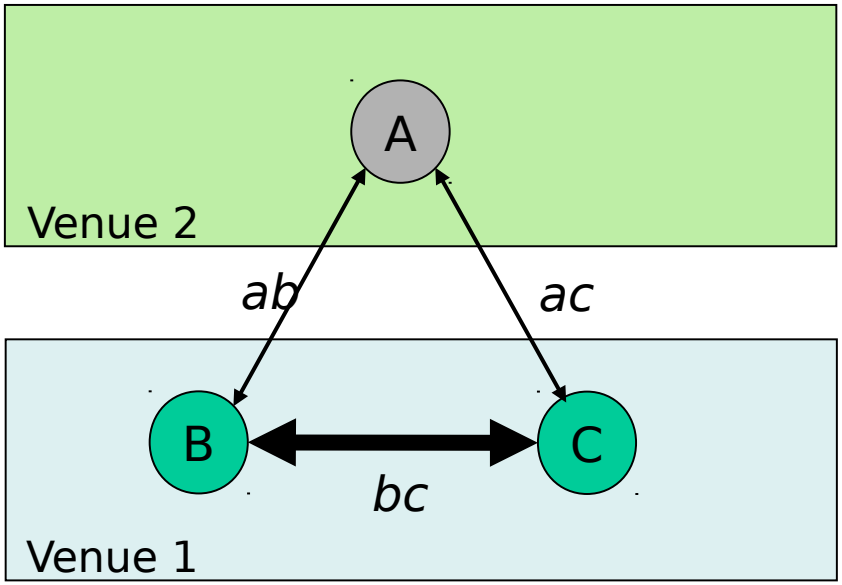
3rd Man out

1. Empirically support phenomenon
   - Contact Frequency
   - Situational Knowledge
   - Role in Voting
   - Subjective sense of team membership

3rd Man out

Contact Frequency			
Action	A	B	C
Spoken exchange			
Pass papers			
Exchange files			
url exchange			
assign task			

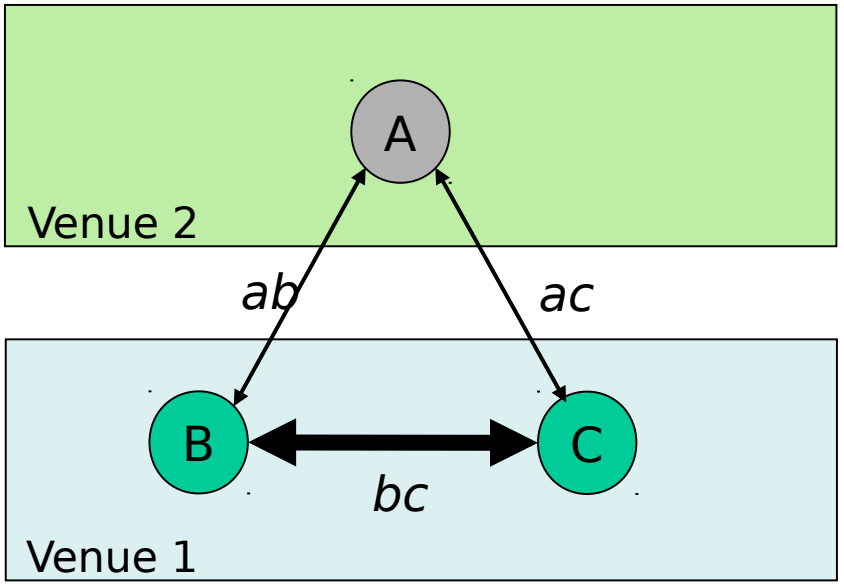
Situational Knowledge			
Knowledge of:	A	B	C
What tasks others are doing			
Task completion levels			
Subjective notion of degree in loop			
Monitoring others frequency			
share task			



3rd Man out

Role in Votes			
Survey question:	A	B	C
How much weight does x carry in discussion			
How often x gets the floor			
How often interrupted			
Monitoring others frequency			
share task			

Team Membership			
Subjective estimate of:	A	B	C
Contribution level			
How helpful you are to others			
How easy to get x's attention			
How essential to team			



3rd Man Out

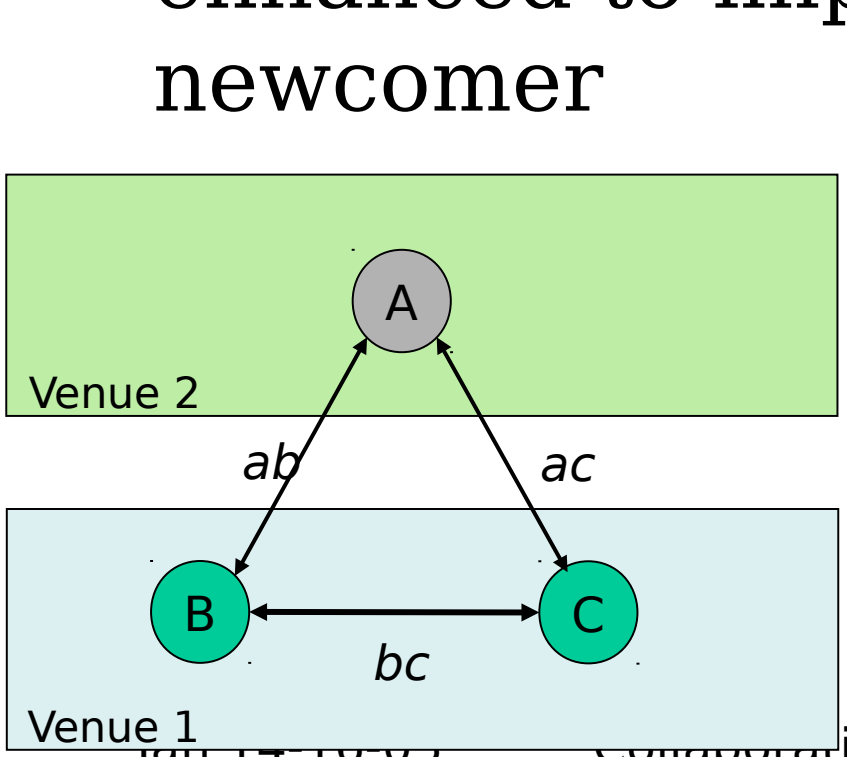
- Identify causes
  - Can’t share paper
  - Weaker attention management
    - Can’t point well
  - Can’t command attention as well
    - Can’t tap on shoulder
  - Imperfect gesture
  - Quality of service related phenomena
  - Recover from interruptions differently
  - Lesser knowledge of context

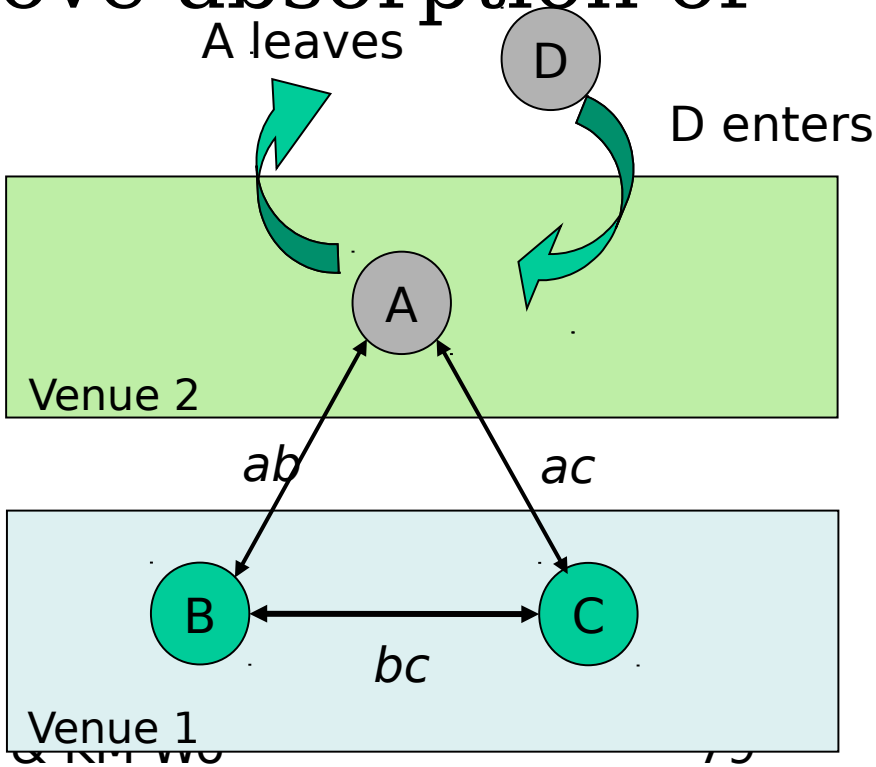
3rd Man Out

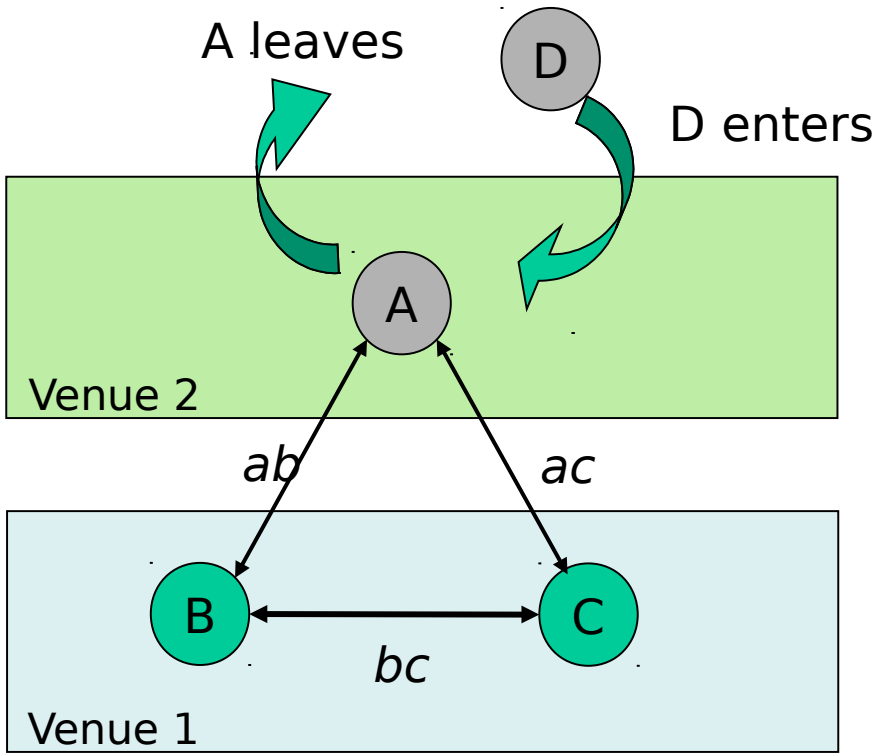
- Possible Repairs
  - Add context camera to show interaction of dyad
  - Attention management via mouse anywhere
  - Everyone work from screen (laptops are closed)
  - Test PIP to see if PIP leads to greater self awareness
  - Attention getting via little light

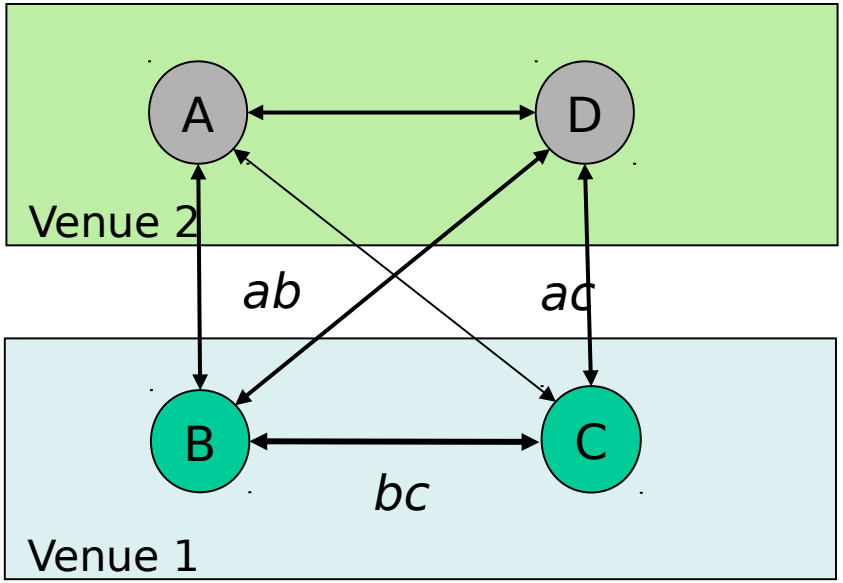
4th Man In

- How can the environment be enhanced to improve absorption of newcomer






A leaves
D
D enters
A
Venue 2
ab
ac
B
C
bc
Venue 1


A
D
Venue 2
ab
ac
B
C
bc
Venue 1

Experimental Plan

- Experimentally discover what subjects need to
  - Solve ecologically natural collaborative tasks, such as logistic problems,
  - Coordinate activities
  - Recover from errors
  - Recover from interruptions
  - Integrate diverse information sources,
  - Make judgments of trust, cultural understanding

Experimental Plan

- Measure performance using new methods of visualizing activity
- Test conclusions by modifying the design of our collaborative environments and retesting performance.
- Integrate with theory of Distributed Cognition and Coordination Theory

Experiments

- Subjects perform ecologically natural experiments
  - Make group itinerary - VTC to Venue 1
  - Compose a PowerPoint presentation – VTC to venue 2
  - Interview candidate

Observe and Measure

- Quantify by statistically examining pre and post tests